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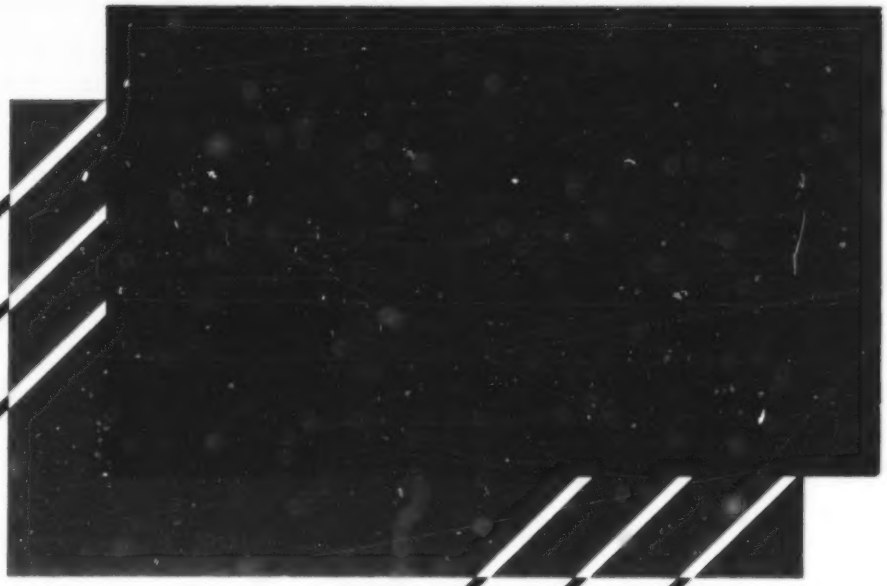

Canada

OPTICAL TECHNOLOGIES

CD-ROM and Other Compact Discs: characteristics, production and market

by

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The views expressed in this report are those of the authors.

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INTRODUCTION

New optical technologies are revolutionizing the information industry and the spread of information by calling for a new look at some of the products and services used to carry this information. If optical discs are to be successfully introduced, however, it is essential to have a good understanding of their characteristics and the applications in which they perform best.

The three objectives of this document, prepared as part of a research program carried out by CWARC on optical discs and more specifically CD-ROM discs, are as follows:

1. to introduce the reader to optical technologies by presenting the main aspects of this new sector of the information industry;

2. to advise potential users and developers about possible compact disc applications and target markets;

3. to promote an exchange of ideas, indicate avenues for cooperation and define areas for future research.

The aspects dealt with in this text are organized into three chapters which provide an overall picture of optical technologies:

I. Compact discs: technical aspects

II. CD-ROM production process

III. The optical technology market

During the spring of 1988, CWARC produced jointly with the Treasury Board of Canada, a CD-ROM with nearly 6 500 entries in office automation related fields. This data collection is a small portion of the Integrated Service of Information Resources (ISIR) database. ISIR combines documentary and stragegic information, document management and database services. CWARC also demonstrates consultation of databases from ISIR's CD-ROMs for any interested readers. Additional information on optical technologies will be provided as soon as it becomes available.

I COMPACT DISCS: TECHNICAL ASPECTS

1. Origins of CD-ROM

CD-ROM technology originates mainly in the field of electronic entertainment equipment, due to the many technical features borrowed from audio compact discs. However, CD-ROMs differ in that, for use in the computer industry, programs have had to be developed to access and search the data stored on them.

1969 Philips starts research into recording images, sound and text on optical discs using the high precision of a laser beam.

1975 Philips manufactures the first prototypes of videodiscs capable of storing an image using a laser reading process.

1978 Launching of first videodisc, known as Laser Vision System.

Final form of the audio compact disc is defined as 1 hour of music on a 12-cm diameter disc.

Philips and Sony agree to set a world industrial standard for compact discs.

1980 With the proven feasibility and acceptance of the CD-audio, the CD-ROM concept becomes more attractive.

1981 Prototype of an audio CD is presented at the international sound festival in Paris.

1983/ 1984 Philips and Sony begin marketing the first compact discs and laser players.

1984 Philips presents the first CD-ROM prototypes.

1985 First CD-ROM data bases and drives appear on the market.

1986/ 1987 Publishers and distributors increase participation in large-scale marketing of optical products (data bases and reference works on CD-ROM).

2. How a CD-ROM works

2.1 Data recording

A CD-ROM is a polycarbonate disc 12 cm in diameter, 1.2 mm thick, with a 15-mm hole in the centre. Information is recorded on a spiral or on a concentric circle of grooves formed by alternating holes and spaces. The holes, known as pits, are formed by burning the original surface of the disc with a laser beam. Pits are 12 microns deep and 6 microns wide and are 1.6 microns apart.

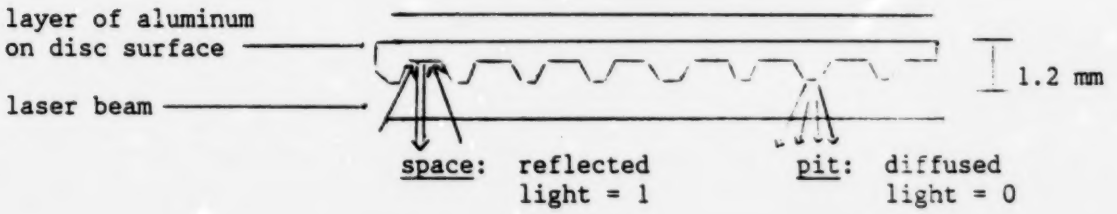
This spacing corresponds to a density of 600 grooves per mm, and it is this high density of grooves that gives the CD-ROM its huge memory space for storing coded data. In comparison, a floppy disk has 4 grooves per mm, while a hard disk has about 100 grooves per mm.

2.2 Data reading

CD-ROMs are read by a low-intensity laser beam (2-3 milliwatts). The beam sweeps the grooves of the disc and, when it illuminates up the pits, it scatters in all directions. When it encounters a space, however, the beam is reflected directly back onto a lens oriented towards a photodiode thus producing a light signal. The modular signal producted by the combination of diffused light ("0") and reflected light ("1") represent the information recorded on the disc. The information produced by modulation of a light signal is converted into binary digital data recognizable by a computer.

Figure 1

Conversion of ligh signals into binary code



2.3 Data transmission/retrieval

The data read by the laser beam and converted into binary form are then "called" by the search program, thus the link between the CD-ROM drive and the micro-computer is essential.

Access to specific data is possible due to division of the total volume of information into a number of files which can be consulted using an index.

Using the search program software accompanying the CD-ROM disc, a keyword can be chosen in the index and the records found in an order that corresponds to the keyword. If the key word chosen by the user is not in the index, the program finds the closest word in strict alphabetical order or allows the user to "scan" the index to find a synonym.

Indexing quality directly affects how quickly and accurately the program can find the data recorded on the CD-ROM. Indexes normally occupy 35 to 50% of the total space on a CD-ROM, and the size of the index increases in direct proportion to the size of the data base.

The software program thus acts as an intermediary between the user and the CD-ROM disc as for other electronic data storage systems. Just as for database and online retrieval software, there is no "standard" CD-ROM search and retrieval software.

3. CD-ROM characteristics

3.1 Memory

The prime feature of the CD-ROM is the huge volume of memory available on each compact disc. A CD-ROM can hold approximately 550 megabytes of computer data. Below are a few comparisons to show the immense memory capacity of the CD-ROM and the audio compact disc:

70 minutes of music in digital form on 1 audio compact disc	=	3 seconds of music in digital form on 1 micro-computer diskette

1 CD-ROM	=	1500-3000 micro-computer diskettes containing digital data
	or	
		250,000 pages of printed text
	or	
		3000 colour slides each with 10 minutes of presentation

3.2 Ready-to-use

This second characteristic enhances the attraction of the CD-ROM because its use requires no previous experience or training, as opposed to on-line search and retrieval. The user is guided through each step of the search by instructions that appear in a window on the screen.

This feature of the CD-ROM allows users to search autonomously, without depending on others to make their queries, as is often the case in searching on-line data bases. And since there are no telecommunications charges, the user can take the time to do a proper search.

3.3 Costs

In terms of production costs, 1 CD-ROM costing $10 has a memory capacity comparable to $150 in production costs for microfiches or $1000 for printing books.

There are, however, 4 cost factors related to CD-ROMs which must be taken into account:

a) the value of the information recorded
b) the cost of processing data in a form that can be transferred to CD-ROM
c) the cost of the CD-ROM drive
d) the volume of the production run in relation to per unit costs

CD-ROMs are distinguished by their one-time, fixed cost (purchase of drive and subscription to discs), which is determined in advance. The user may consult the CD-ROM at any time, with no additional costs being incurred (There are a few CD-ROMs with usage sensitive pricing).

3.4 Equipment required

- IBM or Apple micro-computer with at least 512 K of memory
- CD-ROM drive
- CD-ROM disc
- interface card linking the CD-ROM drive and the computer
- software to access and search the data stored on the CD-ROM

The diagram in Appendix B provides a representation of a PC-based CD-ROM workstation.

3.5 Software

Access to the data on a CD-ROM is achieved using a variety of programs, such as data-base management, word-processing, speadsheets, graphics software, etc. The CD-ROM interface allows software loaded on a CD-ROM to be called directly from the CD-ROM drive. This means that software designed for CD-ROM applications may be developed to be compatible with a given type of computer and stored on a CD-ROM.

3.6 Difference between CD-ROM and CD-audio

There are two main differences between the CD-ROM and the CD-audio:

1. Error detection and correction codes on CD-ROM must be much more precise than on CD-audio because for data one has less error-tolerance than sound for which the human ear cannot discern occasional retransmission errors.

2. Whereas music is normally played from beginning to end, data and text must have a numerous access points, thus requiring a very precise index.

4. Advantages and disvantages

The CD-ROM has a number of advantages over other information storage and retrieval systems, the main ones being:

- enormous memory space
- not sensitive to magnetic fields
- shorter access time than diskette or microfilm
- no risk of losing information as data cannot be erased or modified
- memory capacity allows storage of several types of information on the same disc (text, images, sound)
- space savings
- format easy to handle and transport
- autonomy of consultation (no telecommunications charges, no need to link up with a central computer, passwords and sign-on procedures, etc.)
- fixed, one-time acquisition and operation cost

The CD-ROM also has a few weak points that could be improved:

a) Observation: Access and response time longer than with a hard disk (approximately twice as long)

Commentary: The speed of a CD-ROM is only relatively slow given the volume of information it contains, which is about 27 times as much as a 20 megabyte hard disk. If this factor is considered, search time for a CD-ROM is short (total average access time for a CD-ROM drive is 0.5 seconds).

b) Observation: Absence of standards for organizing data files on disc.

Commentary: There are no norms governing the organization of files for on-line data bases; each producer can organize and structure the data as it sees fit.

c) Observation: Absence of common access and consultation software for all CD-ROMs.

Commentary: The same is true for on-line data bases. Each service has its own software for consulting the different data bases.

d) Observation: Data on a CD-ROM cannot be erased or modified.

Commentary: This feature of CD-ROMs may be seen as an advantage, depending on the user's needs (e.g. archiving, quality assurance, data integrity).

5. Potential applications

Given the advantages of the CD-ROM, this information technology now constitutes an alternative to both electronic and printed information storage systems. The CD-ROM is an ideal product in many fields of application, including:

- data bases (full-text, bibliographical, digital)
- directories (e.g. telephone directories)
- maintenance manuals, equipment inventories
- encyclopedias, dictionaries
- archives (reports, newspapers, etc.)
- replacing microfiches
- parts catalogues

A number of organizations are already using CD-ROM to handle their information, thus demonstrating its versatility. Libraries, documentation centres, governments, companies, law firms and doctors, along with industry, are increasingly taking advantage of the enormous information-management potential of CD-ROMs.

Any user of information may become a CD-ROM user provided their information needs meet at least the following three conditions:

1. frequent consultation of a huge volume of data;

2. simplified query/search, easy-to-use, requiring little or no training;

3. information that can be stored on a CD-ROM without needing too frequent updating (e.g. 3-4 times a year).

6. Other compact discs

6.1 CD-I

The CD-I, or interactive compact disc, is the result of combining image, sound and text on one compact disc using optical technology. Although still in the prototype stage, CD-Is can store music, words, photographs, animated pictures, graphics, computer programs and text.

The physical format of the CD-I will be the same as that of the CD-ROM.

The CD-ROM has now evolved to the point where it can contain both textual information and videotex programs, thus giving it some of the features of the CD-I. The Canada Centre for Occupational Health and Safety and the electronic publishing firm Reteaco have already developed a CD-ROM that offers both data-base consultation and display of videotex programs.

6.2 WORM (Compact Disc-Write Once Read Many)

The WORM is designed to allow users to create their own information banks. Data is recorded on an optical disk cartridge, although it cannot be erased. WORMs are ideal for ever-growing archive requirements, since they are less costly information supports, taking less space and having a much longer life span (at least 10 years) than magnetic tape.

At this time, their memory capacity already varies from 200 megabytes to 4 gigabytes. For certain applications then, such as permanent archiving or financial transactions (audit trails), the fact that data cannot be modified presents a considerable advantage. There are currently four sizes for WORM disc on the market, 3.5", 5.25", 12" and 14". In order to increase data storage capacity even further, systems with a "Jukebox" allows one to use several WORMs at the same time.

IBM is now marketing a low-cost 200 megabyte WORM disc drive compatible with the Personal System/2 micro-computer series, thus making WORMs accessible to a large number of users, who can now compile their own electronic libraries, whether for scientific, business or educational use, and integrate it into a Local Area Network (LAN). COREL, an Ottawa-based company, is marketing an 800 mégabyte WORM. It should be noted that although the term "CD-WORM" is often used for the 3.5" and 5.25" size discs, this is somewhat of a misnomer since the CD format standard is not used.

6.3 DV-I (Digital Video Interactive)

This new CD application, using the same formatting standards as for CD-ROM, was developped by General Electric and first introduced in March 1987. In Spring, 1988 General Electric concluded an agreement with Lotus, Intel and Microsoft to develop an official standard for DV-I thereby enhancing its chances in the marketplace.

DV-I is characterized by its ability to store and retrieve a wide range of information types on one disc, e.g. 72 minutes of movie with sound; 20 minutes of motion picture with 7 hours of voice as well as 5,000 high resolution images; or, 2 hours of video using 1/4 of the screen with the other 3/4 being available for text or 3D images. A standard CD-ROM reader, and PC-AT equivalent plus an DV-I interface card are required to use DV-I.

7. Erasable (rewritable) discs

For applications requiring repeated writing and erasing, the compact disc in its present forms (CD-audio, CD-ROM, CD-I, CD-WORM) is not particularly useful, given the permanent nature of laser-recorded data.

To remedy this problem, research is now underway on an erasable optical disc. In the short term, the optical disc will be a fairly low-cost way of storing large volumes of data that can be modified (or deleted) at will. In the long term, this may mean that magnetic disks (diskettes and hard disks) for storing and updating data will become obsolete.

Two recording and erasing techniques are currently under development: phase change and the thermo-magnetic-optic process. In the phase change process, a laser beam induces a reversible change on a tellurium film. Information may be recorded in the differing reflectivities of the two phases. The thermo-magnetic-optic technique combines the laser-reading process and recording by means of magnetic film. The possibility of rewriting data as often as required would increase the versatility of the optical disc, giving it access to the market currently held by magnetic devices for storing digital information.

There are already a number of manufacturers competing in the erasable disc market utilizing magnetic-optic processes. Among others, Maxor which already has two commercial erasable discs units and the market, i.e. 3.5" and 5.25", offers storage capacities from 160 megabytes to 1 gigabyte. Firms such as Verbatim, Kodak, Sony, Nikon, Tandy, Matsubita, Olympus, Quantex, Philips, to name others, have announced projects to develop, prototype and/or market erasable discs.

II CD-ROM PRODUCTION PROCESS

The main purpose of this chapter is to present clearly and simply the stages in producing a CD-ROM product and to explain the role of each organization involved in the production process. We shall emphasize the technical aspects of CD-ROM production, and thus other aspects of the creation of data bases using optical technology, such as production costs, distribution, marketing, legal matters, etc., will not be covered in this chapter. The entire process is explained, from the initial stage of data collection at the original source to the final stage of distributing copies of the CD-ROM.

The diagram in Appendix A shows these production stages, with the role of each participant.

1. Data collection, analysis and verification

Data to be recorded on the CD-ROM are first chosen in an original source of information stored on another medium (e.g. on-line data base) or, if they do not exist in another form, they are created, classified and structured to form a coherent body of information. They are next analysed and verified to ensure there are no errors or noise in the information to be transferred to the CD-ROM. The processed data are then recorded on magnetic tape in the form of ASCII code.

Input: original information source
Output: ASCII tape
Responsibility: information supplier in cooperation with owner of search software

2. Organization of data

The data on magnetic tape are organized into files allowing them to be searched on the CD-ROM. Development of software or adaptation of existing software for data access and consultation.

a) Sections, chapters, paragraphs and index are organized into individual records and zones that can be search logically by the system.

b) Inverted files and access and search software are then combined to produce a copy of the information that will be entered on the CD-ROM.

c) A directory file and an MS-DOS file are added.

d) Files are organized into a standard format (ANSI)* allowing the data to be transferred from the magnetic tape to the CD-ROM.

e) Search and retrieval software is tested for compatibility and efficiency.

Input: ASCII-coded data on magnetic tape

Output: Series of magnetic tapes for coding of data and the access and search software

Responsibility: Disc publisher in close cooperation with information supplier

Note: At present, each CD-ROM publisher uses its own consultation software to access the data stored on the CD-ROM (there is no agreement or standard for the development of either on-line or CD-ROM data base consultation). The same organization may be both software supplier and publisher.

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* ANSI: American National Standards Institute

3. Pre-mastering

Information on magnetic tape is organized into data blocks of 2048 bytes. Data is coded by adding control codes to detect and correct errors as well as for synchronization and initialization according to the CD-ROM standard. These codes are then combined into the individual data sectors recorded on the tape.

Input: data files on magnetic tape
Output: master tape
Responsibility: disc publisher

4. Mastering

Fabrication of the master disc that will be used to produce all the CD-ROMs. Coding of digital data by means of a laser beam which etches pits and leaves intact areas (lands) on the surface of a glass disc coated with a photoresistant material. Alternating light reflection according to a specific order of pits and lands during reading by the laser beam corresponds to binary-coded digital data which can be recognized by search software.

Input: 9-track master tape
Output: master disc
Responsibility: disc manufacturer

5. Mass production of discs

In this final production stage, the master disc is reproduced on a nickel plate and several original copies (also called negatives) are produced. These copies are next turned into stampers (also called positives). Using an injection moulding process, the stampers are used to produce a specific number of polycarbonate CD-ROMs. Each disc is then given an aluminum

coating on which is placed a label with the following information: title, author, copyright, publisher, updating validity period, disc manufacturer, and then the entire disc receives a protective lacquer coating.

Input: master disc
Output: CD-ROM
Responsibility: producer of CD-ROM copies

6. Distribution

CD-ROMs are currently purchased directly from the information supplier, on a subscription basis, although they may also be ordered from the publisher if the latter has a retail distribution network, as is the case when buying books.

When several thousand CD-ROMs become available, however, this purchasing method will no longer be adequate for the resulting mass market. It will then be possible to purchase CD-ROMs in specialized outlets (CD-ROM stores) as is the case for audio CDs sold in record shops.

Input: packaged CD-ROM
Output: CD-ROM available at point of sale
Responsibility: information supplier or disc publisher or perhaps, in the future, a CD library

III OPTICAL TECHNOLOGY MARKET

1. Characteristics

The characteristics of optical discs make them ideal for a number of potential applications in various information market niches. In this section, we will present the basic structure of two components of this market, the open and closed markets. This may be a useful distinction to better define the marketing potential for compact discs.

1.1 Open market

The essential feature of the open market is that there are no conditions on access and use apart from willingness to pay the required price, i.e. there are no non-economic barriers in this type of market. The desire or ability to pay the price asked comes more from a personal or organizational decision, as is the case with other decisions of an economic nature.

Production of information (creation, storage in memory, distribution and/or consultation) in the open market is aimed at four sub-markets: mass consumption, business, education/training and research.

1.1.1 Mass market

The main characteristics of this market sector are:

- economies of scale due to mass production and distribution of a wide range of information products
- ease of use
- products are ready to use
- selling price of products under $1,000 (hardware and software)

- information products of an educational and/or recreational nature

- products available in pre-packaged form

These characteristics depend on penetration of the mass market by optical products. To date, only audio CDs satisfy these criteria, although other products (CD-ROM) will be able to meet them around the end of 1988.

1.1.2 Business market

The main differences between the business and mass markets are:

- information products for specialized rather than general use

- timeliness, accuracy and relevance of information are very important and influence price (and thus profitability of products)

- regular updating of information

- higher price per unit of information

- several levels of service

- direct access to information in real time may nevertheless still be required

- exclusivity of information may be an important factor

If optical technology is to penetrate the business market, information products must be designed for specific segments of that market.

The first wave of optical products aimed at the business market is comprised of large reference data bases on CD-ROM, e.g. financial or economic data, performance indicators by country, as well as information not accessible on-line (regarding hazardous materials, etc.).

1.1.3 Education/training market

The main characteristics of this market are:

- information supply related to the learning or research process

- public-sector institutions play a dominant role in the acquisition and spread of information (intermediary role)

- potential customers expect to have access to information at low cost

- almost all the information available is in the public domain. The electronic medium represents a time-saving alternative, but users cannot or will not exchange savings in time or work for the purchase of electronic information.

- approach based on collaboration and cooperation in creating data bases

Optical technology will be successful in this market provided:

- products have positive points significant enough to:
  . replace information products available on-line
  . allow products not available on electronic media to penetrate the market

- use of products requires little or no on-line search experience

- prices are low enough to enable individuals and small organizations to purchase products in this market

Point of interest*

Producers of information on CD-ROM (over $2000) for the business market were surprised to find that a significant number of their initial customers were from the education sector. Libraries have apparently found a number of advantages to CD-ROMs over on-line consultation methods.

Some of the reasons for this preference, in the authors' view, are:

- possibility of returning to a more traditional approach based on information supply, as opposed to the on-line approach, based on demand

- administrative costs: on-line consultation does not guarantee immediate payment for search time, and non-payment or late payment slows down the inflow of revenue

- greater stability for budgeting and defining use-time allocations: the cost of a CD-ROM is fixed and one-time, as for a printed work, while on-line consultation involves variable costs that are harder to control

- information products acquired with public funds are used and re-used by all while the results of on-line consultation are geared to the profile of a single user and may thus not be useful to all

- the CD-ROM gives the user more autonomy, thus saving on personnel costs (for connection and searches)

---

* This note also applies to the research market sector.

1.1.4 Research market

This sub-market shares some characteristics with the business and education sectors. It resembles the business market, except that the buying power (or the will to buy) of clients is much lower.

This is mainly due to the fact that, for many researachers and research institutions, it is either possible or a common practice to replace the cost of acquiring information by a given amount of additional work. For example, a researcher can easily spend several hours or days consulting reference works (each day being equal to a cost of $80 if the researcher is paid $10 an hour), instead of paying $40 to $70 for an hour of on-line research.

The research sector also shares the following characteristic with the education/training sector. Many of the information products in these two markets are costly (in money or time), while the direct economic value they generate is small. The long-term indirect advantages of access to up-to-date information in the research sector are difficult to quantify and justify in this sector, which is currently plagued by a lack of resources.

1.2 Closed market

In the markets termed "closed", access to and use of information are governed by non-economic criteria. Buying power does not automatically guarantee access to information. Closed markets are of two types, closed user groups and in-house markets.

1.2.1 Closed User Groups

Admission to a closed user group and the right of access to information sources (data bases and/or networks) are governed by criteria defined by the group.

Examples of such groups are electronic fund information and transfer systems for financial institutions (e.g. SWIFT), researchers and organizations belonging to ARPANET, libraries and documentation centres which exchange catalogue data using OCLC and UTLAS, and the CPIC data base used by Canadian law enforcement bodies.

The information exchanged within these groups is normally very valuable and/or confidential, calling for fairly elaborate security measures such as codes. As a result, the needs (and ability to pay) of these groups are important factors in stimulating the development of electronic information support and distribution systems.

1.2.2 In-house markets

The operations conducted in this information market normally remain within an organization. Such organizations are usually quite large, and so are their information requirements (data bases and/or telecommunications networks). Whether the data has to do with inventories, product catalogues, customer records, etc., in-house markets have a number of common characteristics, e.g.:

- a large volume of informatin in electronic form, often complemented by microforms

- a large number of units spread over several locations within the organization which must have access to the information at the same time

- electronic information systems are linked or form a sub-set of the organization's operations and transactions network

- users have many points of access to the information

- need to store data (archiving)

- much of the information has a fairly long life cycle (over 3 months)

- the confidential and/or valuable nature of the information means there must be adequate security measures

At this time, many organizations in the public and private sectors store their internal information production and transmission activities both on paper and electronically. This situation represents a good potential market for optical technology. It should also be borne in mind that this technology may be used for personnel training. This sub-sector is constantly growing. Optical discs may carry many types of information, e.g. automobile repair manuals, equipment maintenance manuals, flight simulator data, and so on.

2. Marketing opportunities for optical products

The market for optical technologies is divided into two development and marketing streams: one aimed at micro-computers (compact discs) and one targeting mini and mainframe computers compatible with 12 or 14-in optical discs.

2.1 Compact discs

Compact discs are already in use in several distinct markets, and there is a widely accepted convention in the industry for designating the various types of compact discs. The letters "CD" stand for "compact disc", followed by a hyphen "-" and the letter or letters that follow indicate the application. The industry currently recognizes the following areas of applications:

- CD-audio
- CD-ROM (Read Only Memory)
- CD-I (Interactive)
- CD-V (Video)
- CD-WORM (Write Once Read Many)

The section that follows will deal with market opportunities for the CD-ROM due to its rapidly growing popularity.

2.1.1 CD-ROM

Perhaps no other product has had such a powerful impact on the information industry and spread of information as the CD-ROM. As was the case with the advent of on-line data bases in the late 1960s, which revolutionized the information industry, the CD-ROM will profoundly change our approach to information.

In the optical products range, the CD-ROM appears to offer the most opportunities for applications, both in open and closed markets.

Commercial applications for CD-ROMs in the open market include:

- secondary data bases (bibliographies, catalogues, reference works)

- source data bases (digital, factual, documentary) giving direct access to information such as laws and statutes, public sector policies, jurisprudence, geographical data, electronic maps, financial and stock exchange information, etc.

- directories and "yellow pages"

- rates, tariffs, schedules, etc.

- manuals (administrative, maintenace, etc.)

- mass market products such as the Grolier Electronic Enclyclopedia, the Microsoft Bookshelf (10 reference works on 1 CD-ROM compatible with 14 word-processing programs)

- large historical or retrospective data bases

- data bases on magnetic tape used on university campuses through a central computer (e.g. BADADUC)

There are already over 150 different CD-ROMs on the market. Although some are only demos with 20 to 40 megabytes of data, most contain reference works and data bases that are already popular on other types of storage and for which a range of potential users was identified with a view to conducting a trial with the CD-ROM.

Currently, the CD-ROM appears to be the compact disc that offers the widest range of opportunities on both open and closed markets.

Commercial opportunities for CD-ROMs in the closed market include:

- replacing large series of microfiches used in the wholesale and retail trade (automobile parts, pharmaceuticals)

- linking a CD-ROM to a point of sale to provide prices, codes, product descriptions, etc. (EFT/POS systems)

- transmitting confidential coded information (embassies, consulates, etc.)

- rates, tariffs, schedules

- use by public-sector bodies which must transmit the same information at the same time to a number of locations in Canada, particularly to remote areas; this might also apply to multinationals (manuals, procedures, equipment maintenance)

The CD-ROM is essentially a publishing medium. Its popularity in publishing circles is based on such factors as:

- the nature of data bases or works to be recorded on CD-ROM

- distribution characteristics

- frequency of publication (updating)

- volume of information

- means of accessing and consulting data

Whether the target market is a closed group of users (network) or a group within an organization, CD-ROM is an information medium that may be seriously envisaged when the following conditions are satisfied:

- 100 different users or locations to be served

- volume of data exceeds 20 megabytes

- updating annually or quarterly (occasionally monthly)

2.1.2 CD-Audio

CD-audio is currently a strongly growing industry throughout the world, including Canada. Canadian CD-audio producers include CINRAM, Praxis and Disque Amérique. CD-audio technology is well established, and strong growth in this area is based on a number of factors:

- consumer buying power is rising, and a growing share is being devoted to the purchase of electronic recreational equipment

- several models of disc players available at varying prices

- almost all new classifical and popular records are issued in a CD version

- a retail sales infrastructure is developing

- relatively high profit margin for manufacaturers

- optical technology offers a number of advantages over conventional technology, and there is as yet no threat of potential competition from digital audio tape (DAT)

- one basic standard accepted by the industry (Philips and Sony)

It is predicted that CD-audio production in Canada will rise from 3.3 million in 1986 to 7.7-9 million in 1987, and reach 24 to 30 million in 1990.

2.1.3 CD-I

CD-I (Compact Disc Interactive) is an optical technology application with the following characteristics:

- a part of a compact disc family with the same physical standards

- designed to containe different types of information (various combinations), such as text, graphics, sound, images and software

- players may be connected simultaneously as audio and video devices

- mainly aimed at mass consumption and education market

While several CD-I prototypes exist, the industry is currently attempting to define CD-I standards and technical specifications. CD-Is are not expected to be available on the market before 1988.

2.1.4 CD-Video (CD-V)

Suppliers of electronic recreational equipment, videocassettes and records appear to have joined forces to launch the "video" format for compact discs. CD-video is available in three formats, i.e. 5", 8" and 12". The latter two can be played on a videodisc unit connected to the sound output of the television set.

A 5" CD-V sells for $7 while 12" CD-V with 120 minutes of video is available at $30.

Hybrid optical players (capable of playing both CD-V and CD-Audio) are available on the North American market, at approximately $US 700-800. These devices may also play 8 and 12-inch videodiscs. A CD-V player costs approximately $US 700. Pioneer, Sony and Magnavox are already selling CD-V players.

The first wave of CD-V products will probably be aimed at:

- the music industry, for promoting video clips

- retail point-of-sale promotion

- short educational and training messages

There are too many unknowns at the present time to speculate further about the content of the electronic information that will be available in the CD-V format.

The following factors should, however, be taken into account:

Negative points

- North American consumers currently own over 44 million videocassette players, so why change to another technology?

- another "chicken and egg" problem (CD-V discs and players) and the need to undertake a major publishing effort

Positive points

- hybrid CD-Audio and CD-V players should be popular with consumers

- the CD-V is a better and less costly means of large-scale distribution of short videos (for promotional purposes)

- contents cannot be copied onto other CD-Vs without very specialized equipment

- the technical possibility of combining CD-Audio, CD-ROM and CD-V readers into a single device offers the potential of real synergy between these three markets, in addition to economics of scale

2.1.5 (CD)WORM

The demand for memory space linked to personal computers is growing steadily, along with steadily decreasing prices and increased computing power. Up until now, hard disks met the demand for space (in terms of megabytes) for micro-computers, but recently consumers have been able to satisfy their memory-space needs using (CD)WORMs. These discs are aimed at the in-house market in general (small, medium-sized and large organizations).

Drives are available for $400-500, while 5 1/4" (CD)WORM cartridges holding 100 to 200 megabytes sell for $80-100. Higher memory densities in the order of 300 to 400 megabytes are in the works, as are double-sided discs holding 800 megabytes.

The most promising market areas for (CD)WORM include:

- files and back-up copies for LAN networks

- back-up copies in data-storage locations*

- archiving*

- data creation and recording (including all messages or flows of information); input and recording of transaction activity, i.e. audit trails*

- microform replacement (COM files)*

- image recording, particularly in applications where text data and digital images must be stored together (medical, architectural, engineering files)*

- provide permanent proof of transaction data*

Advantages

- possibility of creating, recording and storing large volumes of information with no outside telecommunications charges (since LANs are considered internal networks)

- low-cost memory space per megabyte compared to magnetic media: 1/5 the cost of a 20-megabyte hard disk and 1/25 that of a floppy disk

- juke-box potential

- permanence of recorded data (the authors consider this to be an advantage)

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* These characteristics also apply to 12 and 14-inch WORMs.

- entry into market of IBM for design of drives compatible with its new PS/2 line

- data security

- easy to transport

- long life span, at least 10 years, and some estimates go as high as 30 to 40 years

- possibility of recording and consulting alphanumeric and graphic data (useful in CAD/CAM applications)

Current disadvantages

- drives are relatively slow, and access time thus longer

- high system costs: e.g., a 200-megabyte CD-WORM unit known as "Light File", from Tallgrass Technologies, sells for $10,000, with individual discs costing $265 (however, this system includes many features) but costs are rapidly declining to $500-700 range.

- current versions of MS-DOS and PC-DOS operating systems do not recognize CD-WORM drives as peripherals, and thus as special interface is required. Future versions of MS-DOS should, however, recognize peripherals such as CD-ROM, CD-WORM and CD-I. The fact that Microsoft Inc. is interested in CD-ROM augers well for the compatibility of operating systems with the various types of compact discs.

2.2 Optical discs

The terms "optical disc" or "optical data disc" apply to 12 or 14-inch optical discs used for storage and consultation of data using mini and mainframe computers (videodiscs will not be discussed here).

On the whole, optical discs present a number of advantages, including:

- alternative to conventional recording on magnetic storage
- high volume of memory space
- same low error rate as hard disks, i.e. 10^{-12} per bit
- easier to transport and sturdier than magnetic storage
- longer life cycle (approximately 40 years) than magnetic storage
- simpler and more rapid document search than with microforms

There are a few weak points, including:

- longer access time than for on-line magnetic disks
- technology still in the development stage and not yet tested on a largescale consumer basis

Considerable sums have been invested to place WORM optical discs on the market. Based on a system known as "jukebox", this technology has been slow to penetrate the market, due in part to the fact that it was initially recognized as useful only for large organizations with enormous data processing and search requirements, such as insurance companies. In addition, computer-aided search and retrieval (CAS) of microforms is an efficient, low-cost technology that is currently available and operative.

It is interesting to note that, as in the case of the CD-WORM, indexing appears to present a major challenge. It is one thing to capture a document as an overall image and index it, but it is another to capture the entire content of a document (text, images, graphics, etc.) and index all these pieces of information.

Some industry observers consider the fact that data cannot be erased as a disadvantage, but we feel that this characteristic is an advantage. Specifically, this means permanence of recorded data but updating capacity by the addition of data.

WORMs have the same key advantage of all optical technologies over magnetic storage in that they make it possible to reintroduce into electronic information systems two important characteristics lost when converting data from hard copy to magnetic storage:

- verification (for administrative control purposes)

- authenticity (for purposes of proof)

CONCLUSION

The optical technology market has now moved out of its infancy and into adolescence.

To date, optical technology and products (in particular CD-audio and CD-ROM) available on the market are among the most dependable and resistant media for preserving digital information.

Their compact size and ease of duplication make it possible to mail many copies of them anywhere in the world at a very low marginal cost. A network paralleling that offered by other services (on-line data bases) may thus be created which also gives users considerable autonomy.

As when choosing any type of information storage, however, it is recommended to thoroughly study one's needs in order to derive maximum benefit from the potential of compact discs. A number of criteria should be studied, including: utilization rate (number of users and queries), compatibility of the information product with compact discs (e.g. is the CD-ROM the best medium for a given type of information?), frequency of updating, cost comparisons with other alternatives (hard copy, subscription to on-line data services, etc.)

The CD-ROM production process is based on well-established technology accepted by the industry world-wide; however, indexing and consultation methods, and the organization of menus and user help programs, vary with publishers. This stage of organizing data with access and search programs will no doubt undergo a number of transformations with a view to arriving at a standard for methods used or, failing that, agreement on practices generally accepted by the industry.

It should be noted that the cost of producing a CD-ROM depends directly on how well the original data are organized, i.e. how much preparation is required to allow it to be consulted on CD-ROM. This phase tends to be the

longest and most costly, while the cost of the copy-production phase is relatively low (decreasing as the number of copies increases) and with a lower unit cost, it is of course possible to make more copies.

The fact that CD-ROMs can benefit from CD-audio developments is a unique characteristic. The identical format has meant that CD-ROMs could be produced and marketed using the same industrial infrastructures originally created for CD-audio. Moreover, marketing CD-ROMs was easier due to market penetration by the CD-audio, which has made people familiar with the advantages of recording data (music or text) on compact discs. In this sense, the CD-ROM market has benefited from spinoffs from CD-audio. It should be pointed out here that hybrid readers (accepting either CD-audio or CD-ROMs) are already on the market.

Although the number of works available on CD-ROM is currently quite limited (about 150-200), the variety of products available is a significant indication of the wide range of possible applications, each of which has true market potential.

The CD-audio market will reach maturity towards the end of 1987. The forecast overproduction of discs this year will cause a decline in the cost of players and stimulate the CD-ROM market by bringing production costs down.

Key factors in the development of CD-WORM and other optical technologies were the development in late 1985/early 1986 of error correction chips and data compression methods. As well, the imminent lauching by Microsoft of a new MS-compact disc market, which is aimed at mass consumption, through the connection of disc readers with personal computers and the operating system (MS-DOS).

Whereas the 1986-1987 period was market by large-scale marketing of CD-ROMs, 1987-1988 seem destined to be devoted to developing the market for CD-WORMs.

Compact discs are new tools accessible to users and designed to offer them more flexible interactivity with large volumes of information, but they should initially be considered complementary to other means of accessing information.

Until the advent of the CD-ROM, electronic distribution of information required:

- considerable investment, which included hardware (mini- and large computers), costly consultation software, large memory capacity and setting up telecommunications networks

- fairly high operating costs in terms of:

  . user documentation
  . user training
  . user support and information services
  . management of user activity, including password control
  . revenue collection

It is true that some economies of scale may be realized through joint use of services such as QL Systems, Dialog or CAN-OLE, along with some optimization of operations. But the fact is that upfront costs are high. Moreover, capital investment must be increased (larger computers, etc.) to serve growing numbers of users.

Admittedly, producing a CD-ROM from a data base may cost between $10,000 and $25,000, but a CD-ROM may be produced quartely for three years at less cost than setting up an on-line network. In addition, distributing information using a CD-ROM transfers the capital investment burden from the seller to the purchaser of information (since the latter must purchase a drive to read the discs).

Once the original master disc has been produced, there is practically no limit to the number of CD-ROM copies that can be made. Thus, a network of several thousand "on-line" users may be supported at a very small marginal cost and with fairly high rates of profit (or cost recovery). It should also be noted that CD-ROM is much more useful than paper or on-line services due to the existence of search algorithms in the software and the freedom of activity of users who do not have to worry about telecommunications and service charges.

On-line information services that offer access to data with a very short life span (financial information, news, etc.), distributed by familiar means (I.P. Sharp/Reuter), have little to fear from CD-ROM competition. Current suppliers of information services/data bases may in fact find it advantageous to distribute their retrospective or historical data using CD-ROMs, with their customers using on-line services to obtain very recent or highly specific information.

The price of CD-ROM drives continues to drop, and drives incorporated in micro-computers (like floppy disk drives) are expected on the market by fall 1987.

The fact that hybrid or multifunction drives are already available will also lead to synergy in optical technology applications as a whole. A unique characteristic of this technology as an electronic information support is that there are many market opportunities and potential applications associated with it. If growth in one market stagnates, this will have little effect on the others, and the industry as a whole wil remain dynamic.

With CD-ROMs, joint publishing activities are both possible and encouraged, resulting in completely different data bases on a single disc. Data base producers that cannot be on-line may thus join forces to offer their services on CD-ROMs.

Furthermore, optical technology linked to personal computers offers a much larger market for electronic information, particularly for those who would never use on-line services.

In the context of North-South aid and the basic need for access to and exchange of information in developing countries, CD-ROMs make it possible to progress to a new stage in the technologies used for large-scale information distribution. CD-ROMs require no costly telecommunications networks. They make it possible to access electronic information using only a micro-computer. Even electricity supply problems may be overcome by using solar energy (batteries) to power micro-computers to which may be connected CD-ROM drives operating on solar energy.

The technology underlying CD-ROMs thus represents real and interesting opportunities for developed and developing countries, since they enable all persons equipped with a micro-computer to have access to large volumes of information at relatively low cost.

The huge memory capacity of CD-WORMs permits joint publishing, i.e. several data bases on a single disc, allowing publishers to share initial equipment and distribution costs.

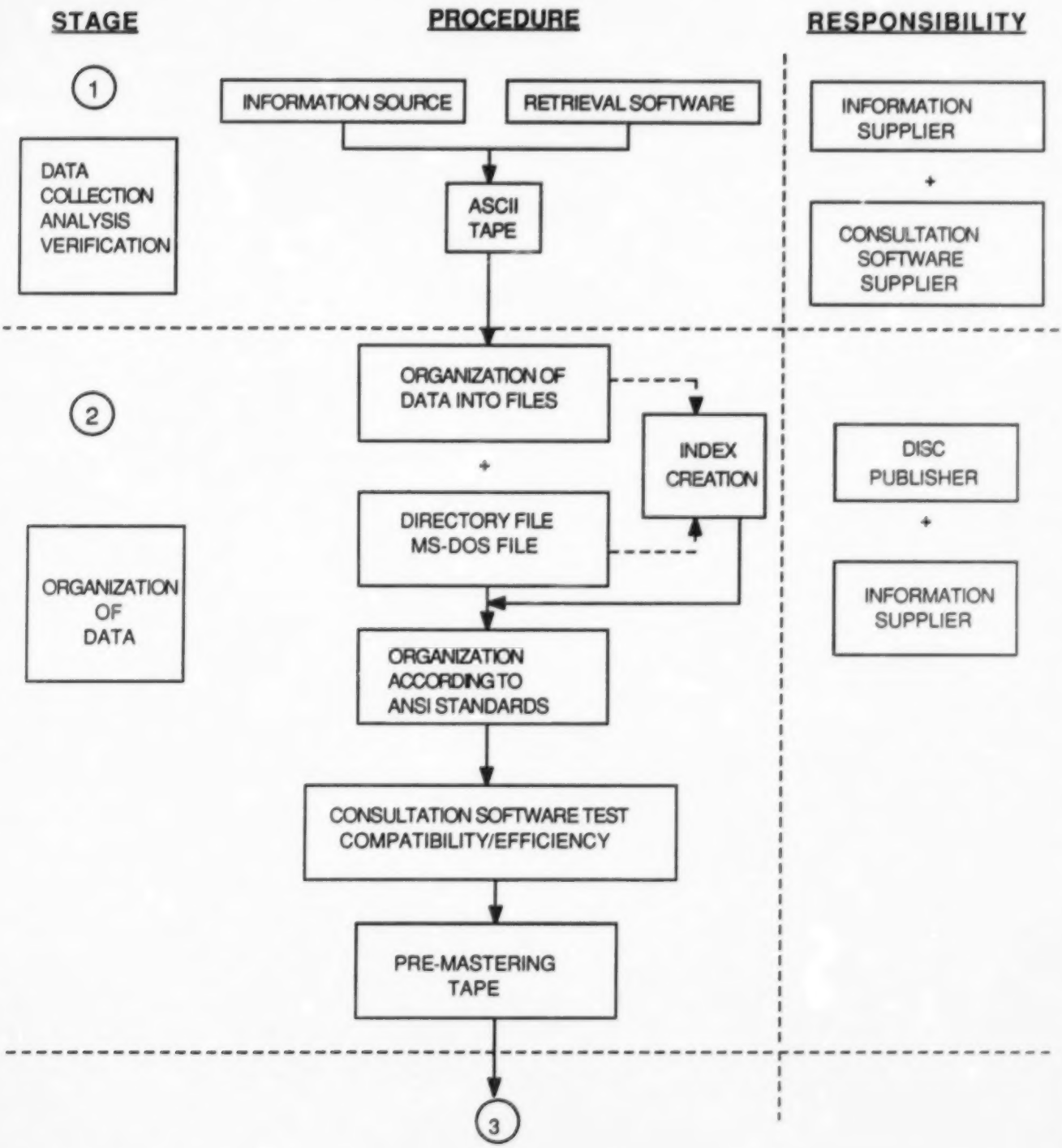
Optical technology thus promotes cooperation and collaboration in the exchange and spread of information between public and private-sector organizations, developing countries, etc.

Furthermore, as Canadian publishers of CD-ROMs have already demonstrated, a CD-ROM product may be entirely bilingual (and thus multilingual). Use of CD-ROMs thus respects and enhances the maintening of cultural identities and differences, while CD-WORMs promote cooperation and collaboration.

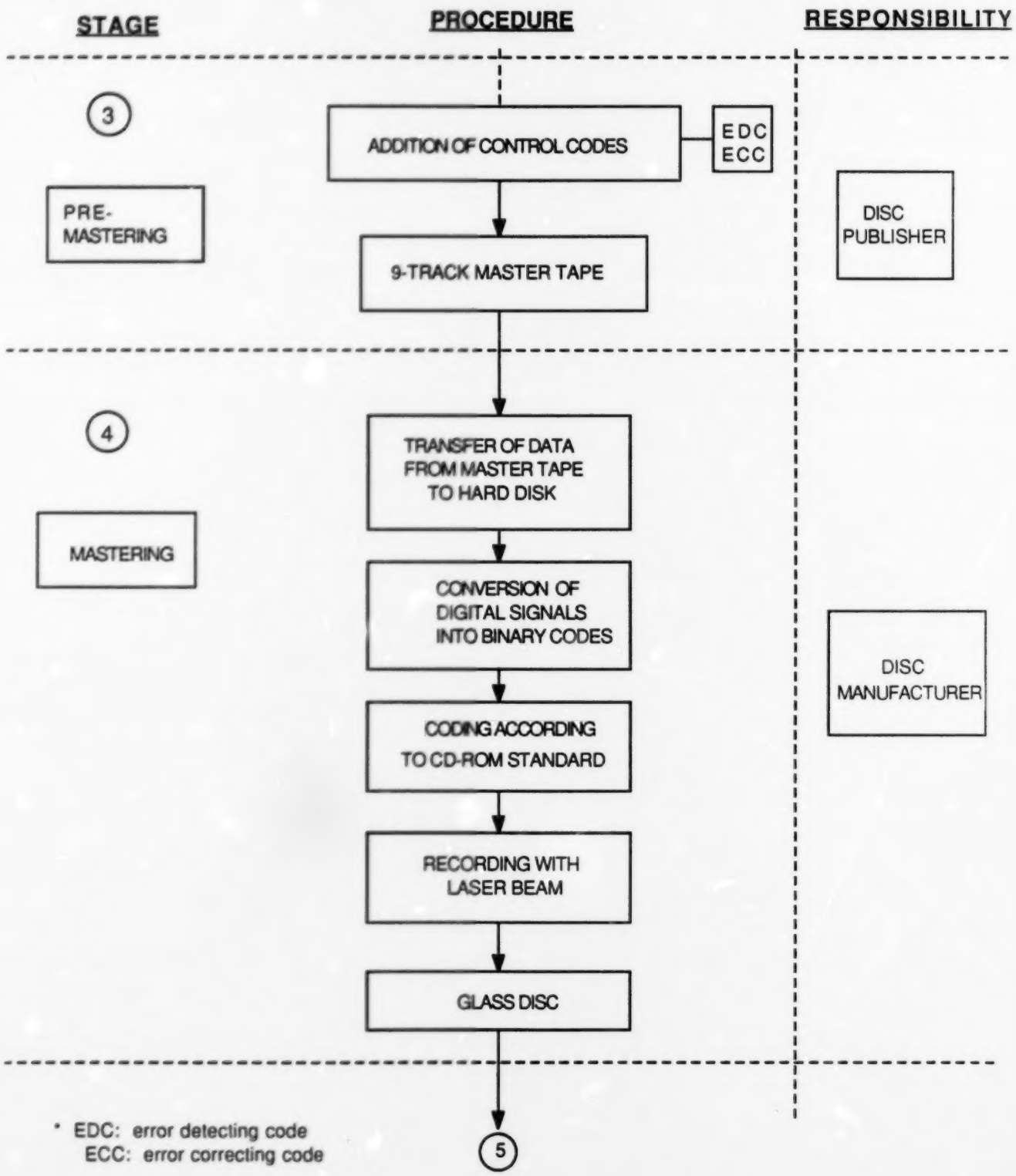
In conclusion, the real challenge is to derive maximum benefit from the democratization and opportunities for exchanging and spreading mass-market electronic information that optical technologies represent.

APPENDIX A

STAGES IN CD-ROM PRODUCTION

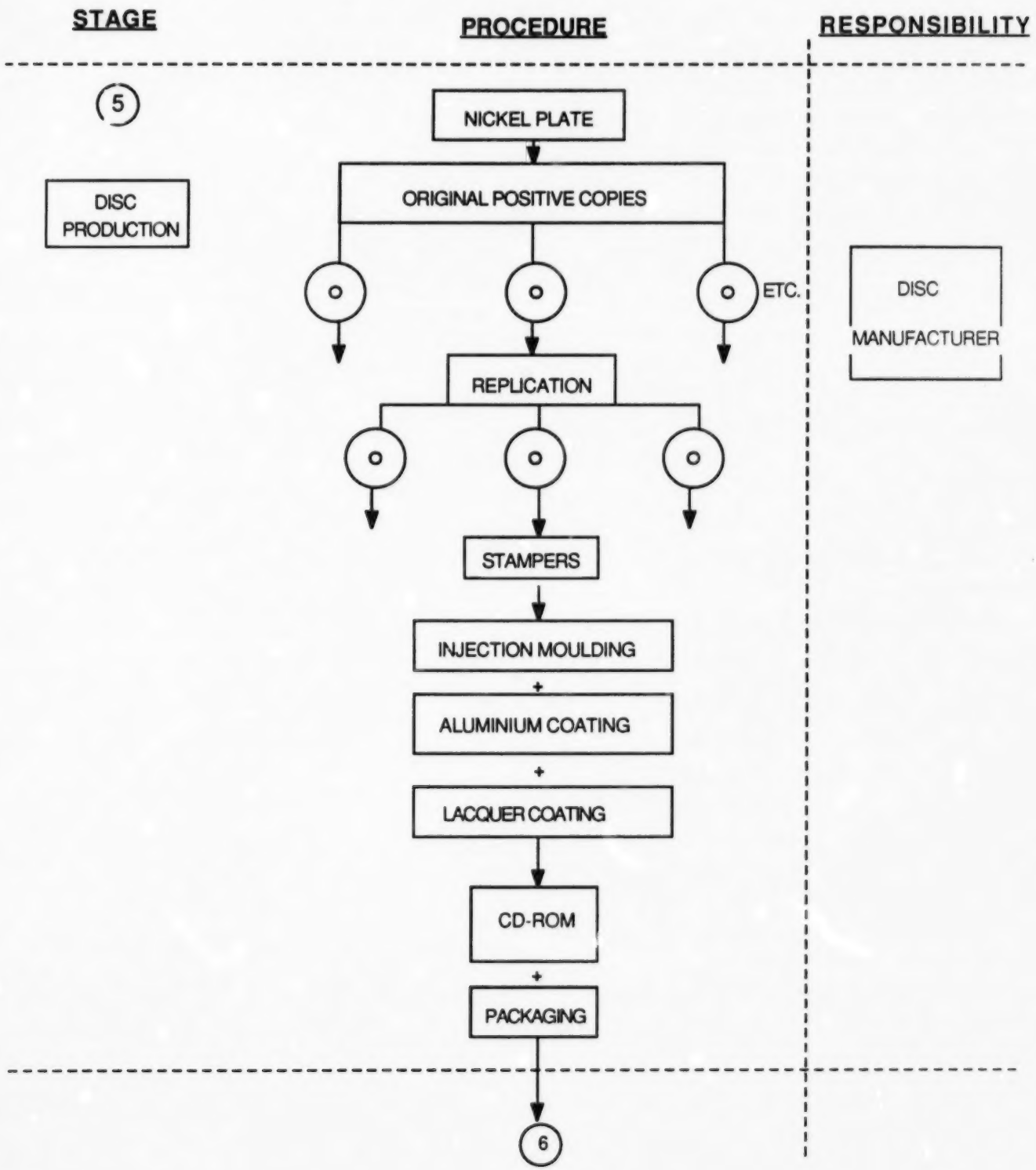


STAGES IN CD-ROM PRODUCTION

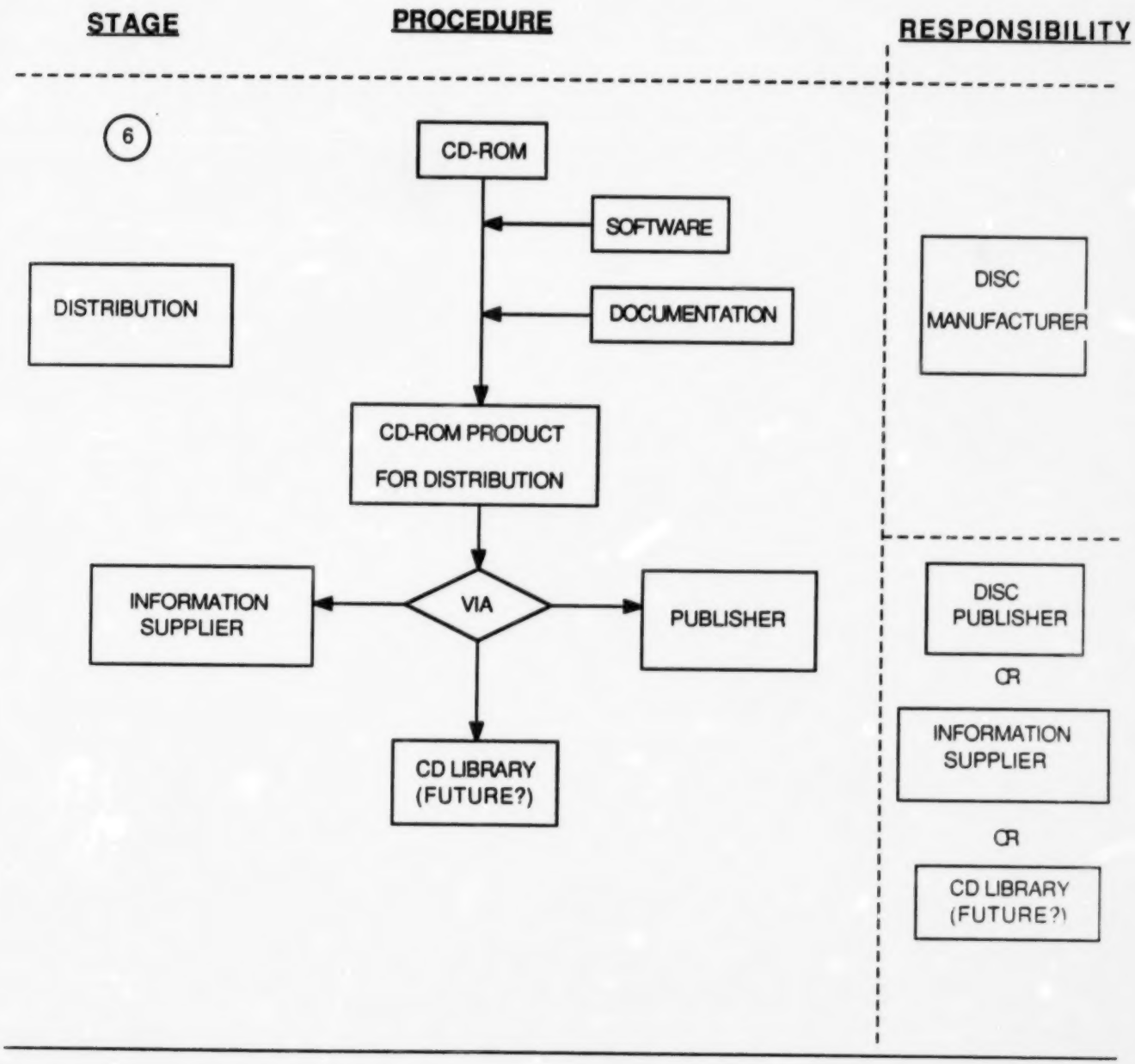


* EDC: error detecting code
ECC: error correcting code

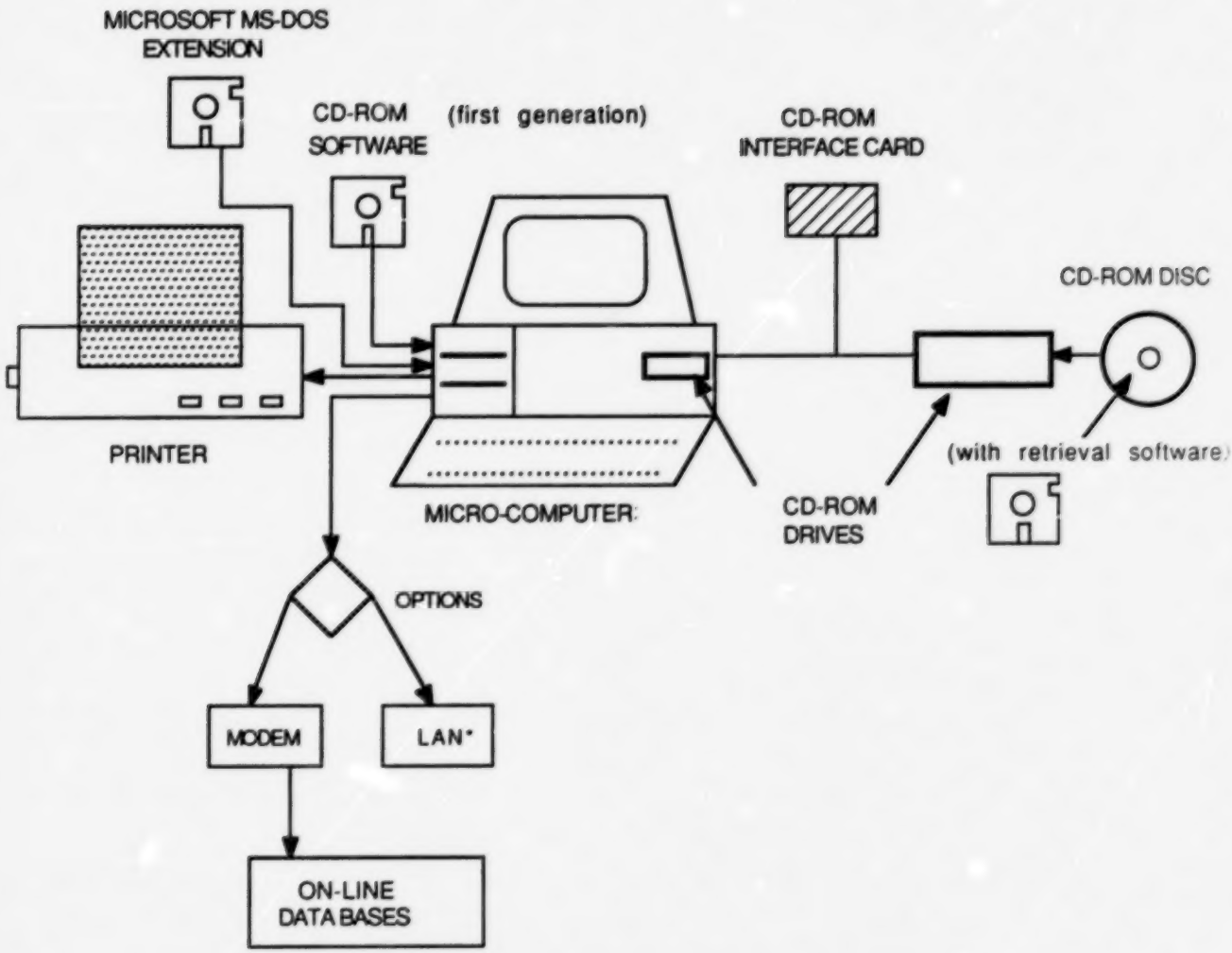
STAGES IN CD-ROM PRODUCTION



STAGES IN CD-ROM PRODUCTION



CD-ROM WORKSTATION



* LAN: Local Area Network

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